U.S. Army Corps of Engineers
Northwestern Division

Missouri River Basin Water Management

Spring Rise Alternatives
2nd Technical Group Mtg.
Bismarck, ND

June 28, 2005

Presentation Topics
Spring Rise Alternatives Summary

- Summary of alternatives modeled to date for the Spring Rise
- Summary of the effects of various plan components/criteria on system storage, lower river flows, and spawning cues
- Similar data as above for special runs

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Plan Components Analyzed

- First Rise
  - None, 31 kcfs, navigation flow + 5 kcfs
- April Flows between the Rises
  - Minimum service, alternative guide curve, current guide curve
- Second Rise
  - Maximum release = 16 kcfs, duration = 2 weeks
  - Proration based on system storage
  - Spring rise preclude
  - Adjustment of flood control constraints

3

Effects Analyzed

- Minimum System Storage during Historic Droughts
- Flows at Nebraska City
- Economic Uses, Environmental Resources and Historic Properties
- Spawning Cue

4

Analysis to Determine Trends Associated with Various Components of the Spring Rise Hydrograph

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Table 2

Table 2. Alternatives Formulated from Table 1 Requirements

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
Existing runs										
MR16FS									46 MAF	
F1 and F2 lie between										
MR16F3									46 MAF	
MR16MN									46 MAF	
M1 and M2 lie between										
MR16M3									46 MAF	
M16F50									50 MAF	
M16F40									40 MAF	
M16F31									31 MAF	
MRBIO3		31 kcfs							46 MAF	
MRBIO4		31 kcfs								31 MAF
MRBIO5										31 MAF
N at end indicates no first rise										
MBIO53										31 MAF
Special Criteria Identified by the Hydrologic Work Group										
MRBP52 - MRBIO5 w/ shorter 2nd Rise						16 kcfs w/ < 2 wk peak				31 MAF
BIO521 - MRBP52 with 21 kcfs max						21 kcfs w/ < 2wk peak				31 MAF
BIO518 - MRBIO5 with 18 kcfs April			< MS							31 MAF

Table 2 (Revised)

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
Existing runs										
MR16FS									46 MAF	
F1 & F2 lie between										
MR16F3									46 MAF	
MR16MN									46 MAF	
M1 and M2 lie betweeen										
MR16M3									46 MAF	
M16F50									50 MAF	
M16F40									40 MAF	
M16F31									31 MAF	
MRBIO4		31 kcfs								31 MAF
MRBIO3		31 kcfs							46 MAF	
New Runs										
MRBIO5										31 MAF
MRBI5N										31 MAF
MBIO53										31 MAF
MBI53N										31 MAF
MRBP32 - MRBIO3 w/shorter 2nd rise		31 kcfs				16 kcfs w/< 2 wk peak			46 MAF	
MRBP52 - MRBIO5 w/shorter 2nd rise						16 kcfs w/< 2 wk peak				31 MAF
BIO521 - MRBP52 with 21 kcfs max						21 kcfs w/< 2 wk peak				31 MAF
BIO518 - Run with 18 kcfs April	not done									
BIO500 - only first	not done									
JS Run with 2nd Rise begin July 1										

Impacts on

Minimum System Storage

During Droughts

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Impact of First Rise on Minimum System Storage During Droughts

- Looked at two spring rise plans – with and without the first spring rise

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
MRBIO5										31 MAF
MRBI5N										31 MAF
MBIO53										31 MAF
MBI53N										31 MAF

- Compared the difference in minimum system storage in each major drought

Impact of First Rise on Minimum System Storage During Droughts

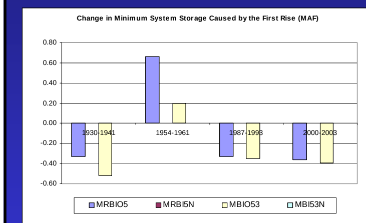

Figure 1

- First spring rise generally reduced the minimum storage during droughts
- Impact during droughts was less than 1 foot in each of the upper three reservoirs
- At full conservation pools, 830 kaf = 1 foot
- At current levels, 560 kaf = 1 foot

Impact of April Flows on Minimum System Storage During Droughts

- Looked at three spring rise plans – with differing April flows
  - Minimum Service
  - Alternative Guide Curve
  - Current Guide Curve

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
MR16F3									46 MAF	
MR16M3									46 MAF	
MBI53N										31 MAF

- Compared minimum system storage in each major drought

Impact of April Flows on Minimum System Storage During Droughts

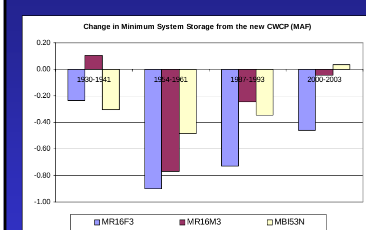

Figure 2

- Comparison is to the current water control plan
- Running minimum service in April uses less water than the current guide curve
- The alternative guide curve also appears to use less water, but some of the impact is likely due to the prorated second spring rise
- Difference between spring rise alternatives was generally less than 1 foot in each of the upper three reservoirs

Impact of Flood Control Constraints on Minimum System Storage During Droughts

- Looked at four spring rise plans – with varying adjustments to the flood control constraints

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
MR16MN									46 MAF	
M1 and M2 lie betweeen									46 MAF	
MR16M3									46 MAF	

- Compared minimum system storage in each major drought

Impact of Flood Control Constraints on Minimum System Storage During Droughts

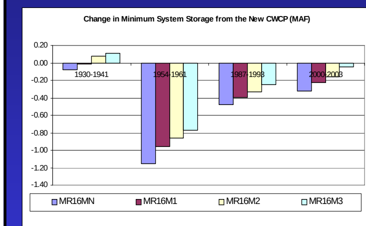

Figure 3

- Comparison is to the current water control plan
- Raising the flood control constraints the full amount of the spring rise uses the most water because it allows the spring rise to be run in many years
- As flood control constraints are reduced, the spring rise gets shuts off more frequently resulting in less water used

Impact of the Spring Rise Preclude on Minimum System Storage During Droughts

- Looked at four spring rise plans – with Spring Rise precludes ranging from 31 to 50 MAF

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
M16F50									50 MAF	
MR16F46 (MR16FS)									46 MAF	
M16F40									40 MAF	
M16F31									31 MAF	

- Compared minimum system storage in each major drought

Impact of the Spring Rise Preclude on Minimum System Storage During Droughts

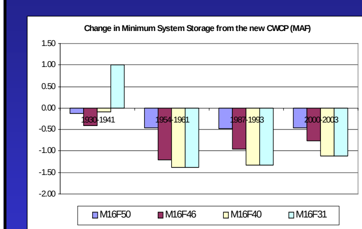

Figure 4

- Comparison is to the current water control plan
- In general, as the spring rise preclude is lowered, system storage during the droughts is lowered due to the ability to run spring rises in more years
- In the 30's drought, the order of non-navigation years changed and an additional non-navigation year was added with the 31 MAF preclude
- In the other 3 droughts, system storage didn't fall below 40 MAF, so the 31 and 40 MAF runs are the same

Impacts on

Flows at Nebraska City

during May and June

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Impact of April Flows on Flows at Nebraska City

- Looked at the current water control plan and three spring rise plans with differing April flows
  - Minimum Service
  - Alternative Guide Curve
  - Current Guide Curve
- Full increases in flood control constraints

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
CWCP										
MR16FS									46 MAF	
MR16MN									46 MAF	
MRBIO5										31 MAF

- Compared the number of days flow would exceed 55 kcfs at Nebraska City

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Impact of April Flows on Flows at Nebraska City

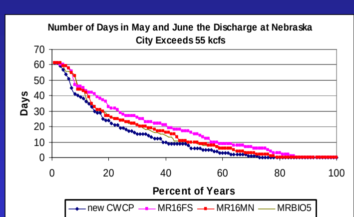

Figure 5

- All spring rise alternatives increase the number of days flow is above 55 kcfs
- Running minimum service between the rises reduces this effect
- Second spring rise is added to existing flow; therefore, the lower the existing flow, the lower the spring rise
- MRBIO5 has prorated spring rise so isn't directly comparable
- Full increases in flood control constraints

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Impact of April Flows on Flows at Nebraska City

- Looked at the current water control plan and three spring rise plans with differing April flows
  - Minimum Service
  - Alternative Guide Curve
  - Current Guide Curve
- Minimum increases in flood control constraints

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
CWCP										
MR16F3									46 MAF	
MR16M3									46 MAF	
MBI53N										31 MAF

- Compared the number of days flow would exceed 55 kcfs at Nebraska City

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Impact of April Flows on Flows at Nebraska City

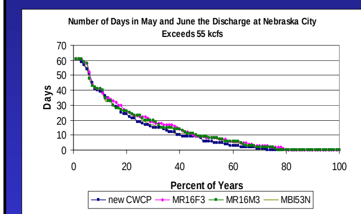

Figure 6

- All spring rise alternatives increase the number of days flow is above 55 kcfs
- Reducing the flood control constraints reduces the difference between the alternatives
- Running minimum service between the rises still reduces the number of days with flow above 55 kcfs
- MBI53N has prorated spring rise so isn't directly comparable

Impacts on

Average Annual Economic Uses,

Environmental Resources, and

Historic Properties

Table 4. Economic use and environmental resource impacts of the spring rise alternatives.

File Name	Impacts 1898-1997	FLD CON	NAVIG	HYDRO	WTR SUP	RECR	TOT NED	YOY	CLD RES	COLD RIV	WRM RIV	PHY HAB	T&P HAB R	WET HAB	RIP HAB	HIS PROP
1898-2003																
NWCP00	MCP300	410.2	9.35	674.3	611.3	87.4	1792.5	2.13	10.3	185.9	50.4	81.4	304.9	157.6	107.8	4905
MRBIO3	MRBIOX	407.6	7.18	673.7	607.7	86.6	1782.8	2.15	10.1	185.8	48.6	82.1	283.9	157.0	106.3	4958
MR16FS	MR160S	408.1	8.47	672.0	607.6	86.4	1782.4	2.13	10.0	185.0	48.8	82.6	298.7	155.7	105.6	5025
MR16F1	MR1601	407.9	8.54	672.3	607.7	86.5	1783.0	2.13	10.0	184.7	49.3	82.5	287.2	154.4	105.9	5017
MR16F2	MR1602	408.1	8.54	672.6	611.2	86.4	1786.8	2.13	10.0	184.7	48.8	82.4	265.6	154.4	106.1	5014
MR16F3	MR1603	407.9	8.55	673.0	607.9	86.4	1783.7	2.13	10.0	184.9	49.3	82.3	251.9	153.1	106.9	5003
M16F50	M16050	408.1	8.25	672.6	607.8	86.6	1783.4	2.13	10.0	184.8	49.2	82.5	295.6	155.9	105.6	5006
M16F46	MR160S	408.1	8.47	672.0	607.6	86.4	1782.4	2.13	10.0	185.0	48.8	82.6	298.7	155.7	105.6	5025
M16F40	M16040	408.1	8.72	671.6	610.9	86.6	1785.9	2.12	9.9	184.4	49.3	82.7	299.8	157.2	105.4	5045
M16F31	M16031	408.1	8.80	671.8	610.6	87.1	1786.3	2.13	10.0	184.7	48.9	82.6	316.5	156.8	105.0	5043
MR16MN	MR16IN	407.6	8.37	674.2	608.0	86.9	1785.1	2.14	10.1	186.9	48.4	82.0	277.6	156.4	107.6	4933
NR16M1	MR16I1	407.6	8.37	674.5	611.4	86.8	1788.7	2.15	10.2	187.8	47.0	81.9	280.6	154.4	108.1	4927
NR16M2	MR16I2	407.5	8.33	674.8	611.4	86.9	1788.9	2.16	10.2	187.5	47.8	81.9	272.0	153.8	108.6	4921
NR16M3	MR16I3	407.5	8.35	674.9	611.7	86.9	1789.4	2.16	10.3	187.3	48.3	81.8	277.6	155.1	107.5	4897
1898-2004																
MRBIO4	MJBIO4	407.3	9.5	673.6	607.3	86.3	1784.0	2.16	10.2	186.9	47.8	82.1	293.9	157.3	106.3	4941
MRBIO5	MJBIO5	405.9	10.3	673.1	607.3	86.2	1782.8	2.15	10.1	186.0	48.4	82.1	281.8	158.3	107.0	4964
MBIO53	MJIO53	407.3	10.3	673.9	607.4	86.8	1785.7	2.17	10.2	186.9	48.2	81.9	284.7	154.9	107.9	4933
MRBP52	MJBP52	407.2	9.8	673.4	607.2	86.3	1784.0	2.15	10.1	186.4	48.8	82.1	305.3	157.9	107.0	4962
BIO521	BJO521	407.5	9.5	672.8	610.8	87.5	1788.2	2.15	10.1	185.1	48.7	82.2	297.6	157.5	106.4	5021
MRBI5N	MJBI5N	405.7	10.3	673.9	607.4	86.8	1784.0	2.16	10.2	186.4	48.7	82.0	305.4	158.1	106.6	4924
MBI53N	MJI53N	405.5	9.7	674.7	611.4	87.0	1788.4	2.17	10.3	186.7	47.6	81.8	310.7	154.5	107.4	4897
	Percent Change From the Value for the NWCP (MCP300 Run)															
	MRBIOX	-1	-23	0	-1	-1	-1	1	-1	0	-4	1	-7	0	-1	1
	MR160S	-1	-9	0	-1	-1	-1	0	-3	0	-3	1	-2	-1	-2	2
	MR1601	-1	-9	0	-1	-1	-1	0	-3	-1	-2	1	-6	-2	-2	2
	MR1602	-1	-9	0	0	-1	0	0	-3	-1	-3	1	-13	-2	-2	2
	MR1603	-1	-9	0	-1	-1	0	0	-2	-1	-2	1	-17	-3	-1	2
	M16050	0	-12	0	-1	-1	-1	0	-2	-1	-3	1	-3	-1	-2	2
	MR160S	-1	-9	0	-1	-1	-1	0	-3	0	-3	1	-2	-1	-2	2
	M16040	-1	-7	0	0	-1	0	-1	-3	-1	-2	2	-2	0	-2	3
	M16031	-1	-6	0	0	0	0	0	-3	-1	-3	2	4	-1	-3	3
	MR16IN	-1	-10	0	-1	-1	0	0	-1	1	-4	1	-9	-1	0	1
	MR16I1	-1	-11	0	0	-1	0	1	-1	1	-7	1	-8	-2	0	0
	MR16I2	-1	-11	0	0	0	0	1	-1	1	-5	1	-11	-2	1	0
	MR16I3	-1	-11	0	0	0	0	1	0	1	-4	0	-9	-2	0	0
	MJBIO4	-1	1	0	-1	-1	0	1	-1	1	-5	1	-4	0	-1	1
	MJBIO5	-1	10	0	-1	-1	-1	1	-2	0	-4	1	-8	0	-1	1
	MJIO53	-1	10	0	-1	-1	0	2	-1	1	-4	1	-7	-2	0	1
	MJBP52	-1	5	0	-1	-1	0	1	-2	0	-3	1	0	0	-1	1
	BJO521	-1	2	0	0	0	0	1	-2	0	-3	1	-2	0	-1	2
	MJBI5N	-1	10	0	-1	-1	0	1	-1	0	-3	1	0	0	-1	0
	MJI53N	-1	4	0	0	0	0	2	0	0	-6	0	2	-2	0	0

Comments on Summary of Uses

- Percent changes for all categories except navigation and tern and plover habitat are relatively constant, and are generally in the range of +/–2 percent
- Navigation data for spring rise runs is flawed. Time constraints have not permitted the required hand corrections to the raw data files from the hydrologic model
- Tern and plover habitat results are based on habitat available in the early 1990's and are not representative of the habitat available today

Impacts on

Spawning Cues

Indicators of Spawning Cue

- Master Manual EIS used a flow/duration combination as a surrogate for spawning cue
  - 20 percent increase of flow
  - 14 days duration
- Other combinations of magnitude and duration could be used
- Actual spawning cue is likely a combination of many factors such as flow, stage, temperature, photoperiod, etc

Indicators of Spawning Cue

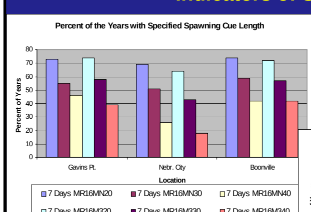

Figure 8

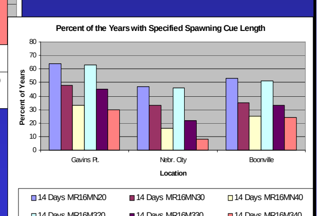

Figure 9

Impact of April Flows on Spawning Cue

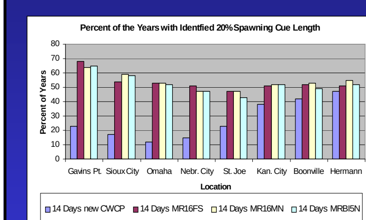

Figure 10

- Higher April flows result in higher magnitude of spring rises, but not necessarily more years with a 20 percent increase in flows
- Relatively little difference between alternatives
- All alternatives meet spawning cue criteria more than 40 percent of the years at all locations

Impact of Flood Control Constraints on Spawning Cue

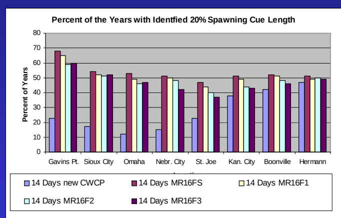

Figure 11

- Number of years meeting spawning cue criteria is generally reduced as flood control constraints become more restrictive
- Difference between alternatives ranges from 2 to 10 percent of years
- All alternatives meet spawning cue criteria more than 35 percent of the years at all locations

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Impact of the Spring Rise Preclude on Spawning Cue

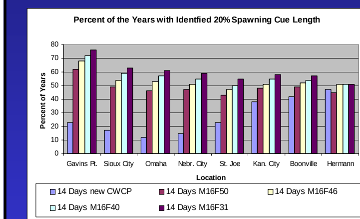

Figure 12

- Number of years meeting spawning cue criteria increases as the spring rise preclude is reduced
- Maximum difference is 11 percent of years
- All alternatives meet spawning cue criteria more than 40 percent of the years at all locations

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Analysis of Special Runs Requested by Technical Working Group

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Special Runs Requested by the Technical Working Group

- Requests received for several additional runs
  - ✓ Shorter duration of second rise
    - ➢ *Duration of the spring rise could not be reduced to less than 9 days due to modeling limitations – this is not a limit in real time regulation*
  - ✓ Greater magnitude of second rise (+21 kcfs)
  - First rise followed by 18 kcfs in April
  - No first rise; winter releases until May 1
  - First rise only
  - Second rise beginning on July 1

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Special Runs Requested by the Technical Working Group

- Alternatives used in Special Run Comparisons

Alternative Name	First Rise		Drop Between Rises			Max Rise	FC Constraints		Max or Prorate during drought	
	None	Nav +5 1 Wk	Min Serv	New GC	Current GC	16 kcfs 2 wk pk	Plus 16	Min. Raise	Max w/ Precl.	Prorate w/ Precl.
CWCP										
MBIO53										31 MAF
MRBP52 - MRBIO5 w/shorter 2nd rise						16 kcfs w/< 2 wk peak				31 MAF
BIO521 - MRBP52 with 21 kcfs max						21 kcfs w/< 2 wk peak				31 MAF

- Compared the difference in minimum system storage in each major drought
- Compared the number of days flow would exceed 55 kcfs at Nebraska City
- Compared the impact on spawning cue

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Impact of Special Runs on Minimum System Storage During Droughts

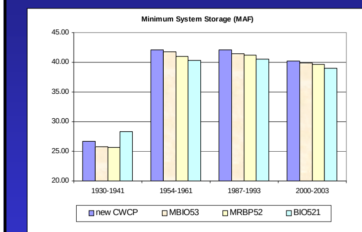

Figure 18

- MBIO53 has different flood control constraints so isn't directly comparable
- Alternatives generally result in lower system storages during droughts than the CWCP
- The higher spring rise (21 kcfs) reduces system storage in 3 of the 4 droughts

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Impact of Special Runs on Flows at Nebraska City

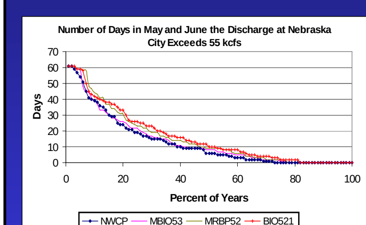

Figure 19

- MBIO53 has different flood control constraints so isn't directly comparable
- All spring rise alternatives increase the number of days flow is above 55 kcfs
- The higher spring rise (21 kcfs) increases the number of days the flow is above 55 kcfs

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Impact of Special Runs on Spawning Cue

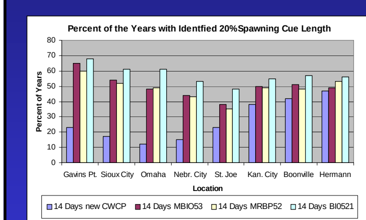

Figure 20

- Spawning cue criteria used was 20 percent increase in flow for 14 days
- All spring rise alternatives increase the percent of years meeting the spawning cue criteria
- The higher spring rise (21 kcfs) increases the percent of years that meet the spring rise criteria
- All alternatives meet spawning cue criteria more than 35 percent of the years at all locations

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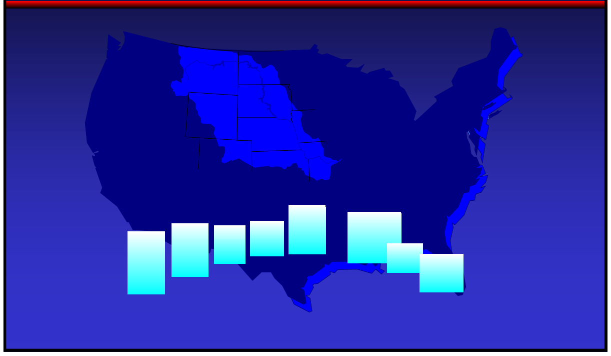
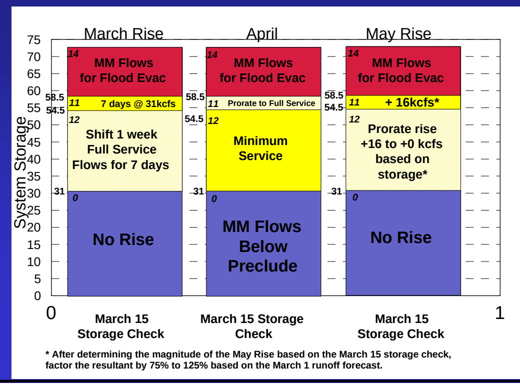
Missouri River Region

Water Management Division

US Army Corps of Engineers





3 – Second Bimodal Spring Rise

Volume of Water Needed for a Full Spring Rise (million acre-feet)

Spring Rise Amount (kcfs)	Weeks at Peak Rise: 2	3	4
4	0.167	0.222	0.278
8	0.333	0.444	0.555
12	0.500	0.666	0.833
16	0.666	0.889	1.111
20	0.833	1.111	1.388

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Combined Impact of Spring Rise Components on Spawning Cue

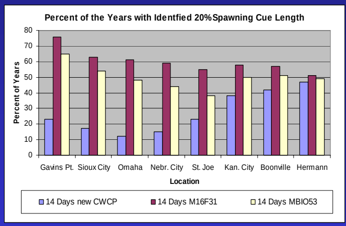

Figure 13

- Both alternatives meet spawning cue criteria more than 35 percent of the years at all locations
- Maximum difference at St Joseph (17 percent of years)
- Minimum difference at Hermann (2 percent of years)

- **M16F31**
  - No first rise
  - Current April guide curves
  - +16 flood control constraints
  - 31 MAF spring rise preclude
  - No proration
- **MBIO53**
  - 5 kcfs first rise
  - Alternative April guide curves
  - Minimal increase of flood control constraints
  - 31 MAF spring rise preclude
  - Proration

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Table 3

Table 3. Current flood control constraint flow values in kcfs and low-increase option for constraints.

	Flow Target for Service Level of 35 (Full Service)	Current Flood Control Target (Reduce to Full Service)	Current Flood Control Target (Reduce to Min. Service)	Low Increase for Spring Rise FC Target (Reduce to Full Service)	Low Increase for Spring Rise FC Target (Reduce to Min. Service)
Sioux City	31				
Omaha	31	41	46	49	50
Nebraska City	37	47	57	55	57
Kansas City	41	71	101	75	93

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Table 1

Table 1. Criteria Provide by the technical work group for alternative formulation.

Criteria	Values to be Modeled		
1st Rise	No rise	Nav. +5 kcfs for 1 wk	Nav. +5 kcfs for 1 wk
Drop between rises	Min. Service	Alternative Guide Curve	MM Guide Curve
2nd Rise – Max.	16 kcfs for 2 wks		
2nd Rise – FC Constraints	Plus 16 to MM	Min change from MM	
Max or Prorate During Drought	Maximum with preclude	Prorate with Preclude	

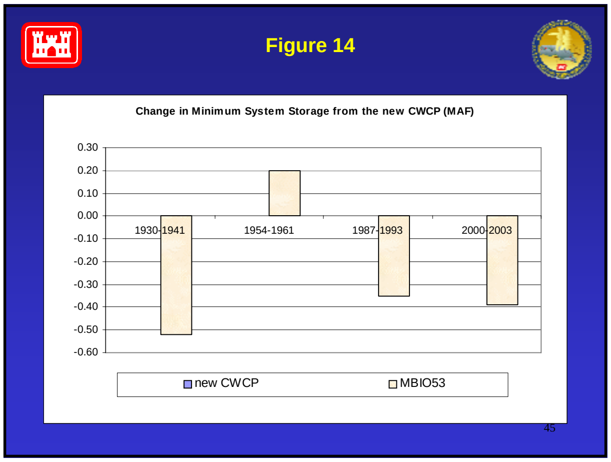
Figure 14
Change in Minimum System Storage from the new CWCP (MAF)
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
1930-1941
1954-1961
1987-1993
2000-2003
new CWCP
MBIO53
45

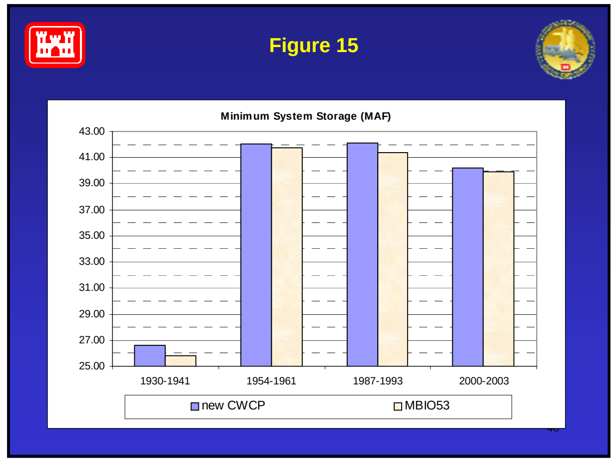
Figure 15
Minimum System Storage (MAF)
43.00
41.00
39.00
37.00
35.00
33.00
31.00
29.00
27.00
25.00
1930-1941
1954-1961
1987-1993
2000-2003
new CWCP
MBIO53

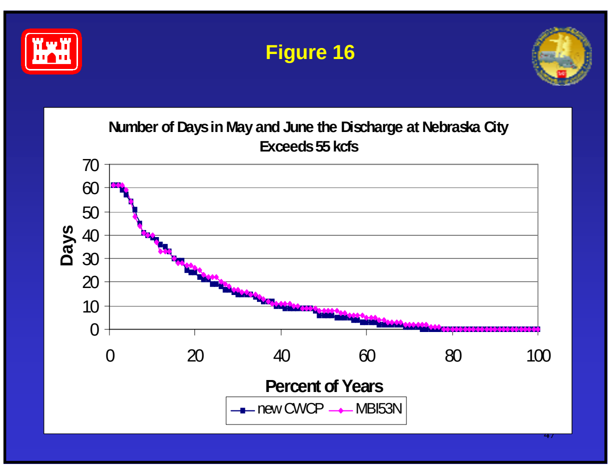
Figure 16
Number of Days in May and June the Discharge at Nebraska City Exceeds 55 kcfs
Days
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent of Years
new CWCP
MBI53N

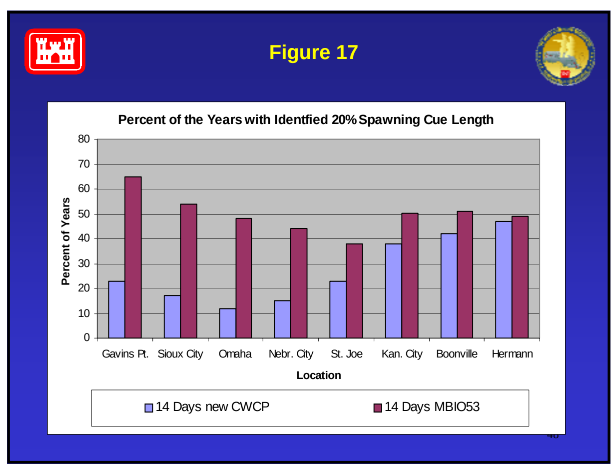
Figure 17
Percent of the Years with Identfied 20% Spawning Cue Length
Percent of Years
80
70
60
50
40
30
20
10
0
Gavins Pt.
Sioux City
Omaha
Nebr. City
St. Joe
Kan. City
Boonville
Hermann
Location
14 Days new CWCP
14 Days MBIO53

First Bimodal Rise
Downstream Crop Damage Risk

- 31-kcfs rise is not predominant in many years when compared to normal releases under the new Water Control Plan; therefore, crop damage risk is relatively unchanged.
- Higher magnitude rises will increase crop damage risk.
- Having the rise start earlier at the 31-kcfs level may increase the crop damage risk as the release during that earlier period could be as much as 15 to 22 kcfs higher than under the new Water Control Plan.

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Service Level between Rises
Frequency of Rise

- Variable, depending on location on the Lower River.

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Service Level between Rises
Drought Storage Levels

- The higher the service level during this period, the lower the storage levels in the droughts. This effect is true primarily due to the lost storage in the first year of the drought due to the one month of increased service. In subsequent years of the drought, the service levels are almost always minimum service due to the relatively higher guide curves of the new Water Control Plan for this period of the year.
- Service levels lower than minimum service will not reduce storage levels as much as the minimum service alternatives.

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Service Level between Rises
Downstream Crop Damage Risk

- The higher the service level in this period, the higher the crop damage risk in this period and during the second spring rise as its release rate is based on the service level flow target requirements during the spring rise.

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Second Bimodal Rise
Frequency of Rise

- Assuming the magnitude continues to be based on 16-kcfs rise, the frequency of the rises can be affected by the drought stop protocols and the downstream flood control constraints.
- As the drought stop protocols limit rises during droughts, the frequency of rises may be diminished.
- As the flood control constraints are not raised as much to accommodate the spring rise, the frequency of the spring rise is diminished.
- Increasing the duration of the spring rise should have little effect on the frequency of the rise.

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Second Bimodal Rise
Drought Storage Levels

- Assuming the magnitude continues to be based on 16-kcfs rise, the effects of the rises on drought storage levels can be affected by the drought stop protocols and the downstream flood control constraints.
- As the drought stop protocols limit rises during droughts, the drought storage levels will be increased.
- As the flood control constraints are not raised as much to accommodate the spring rise, the drought storage levels will be increased.
- Increasing the duration of the rise will further reduce drought storage levels.

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Second Bimodal Rise
Downstream Crop Damage Risk

- Assuming the magnitude continues to be based on 16-kcfs rise, the effect of the rises on downstream flood risk can be affected by the drought stop protocols and the downstream flood control constraints.
- As the drought stop protocols limit rises during droughts, the downstream flood risk will be diminished very minimally.
- As the flood control constraints are not raised as much to accommodate the spring rise, the downstream crop damage risk is diminished.
- Increasing the duration of the spring rise should increase the crop damage risk.

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